CLAIMS

1. A comb-shaped epoxy resin represented by the following
formula (1):

[Chemical formula 1]

$$\left[\!\!-O-X_1-O-CH_2\underset{\underset{Y}{|}}{C}HCH_2-O-X_2-O-CH_2\underset{\underset{Y}{|}}{C}HCH_2 \right]_n \quad (1)$$
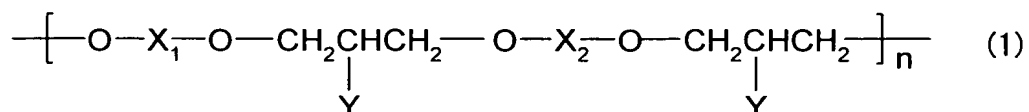
in the formula (1), X_1 and X_2 may be the same or different
and represents a divalent group having a residue selected
from a xanthene residue which may have a methyl group or an
ethyl group as a substituent, a biphenylene residue which may
have a methyl group or an ethyl group as a substituent, a
bisphenol residue which may have a methyl group or an ethyl
group or a halogen atom as a substituent, a hydrogenated
bisphenol residue which may have a methyl group as a
substituent, an alkylene residue and a polyoxyalkylene
residue, and at least one of them is an aromatic residue and
may vary with a repeating unit; Y represents a linear polymer
chain composed of at least one of an ethyleneimine structural
unit and an N-acylethyleneimine unit, or a polymer chain
composed of a polyethyleneimine-polyalkylene ether block unit
or a poly N-acylethyleneimine-polyalkylene ether block unit,
a number average polymerization degree being within a range
from 5 to 2000, and n (number average polymerization degree)
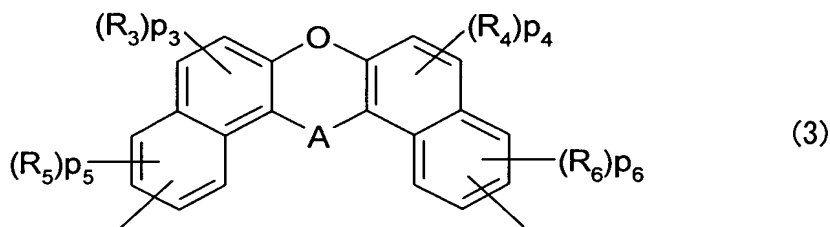
represents an integer of 3 to 200.

2. The comb-shaped epoxy resin according to claim 1, wherein X_1 and X_2 in the formula (1) are divalent groups selected from those represented by the following formula (2):

[Chemical formula 2]


(2)
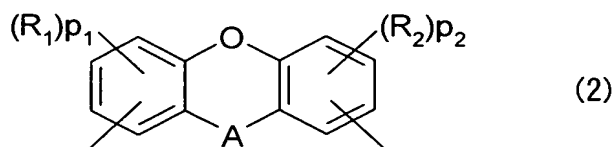
the following formula (3):

[Chemical formula 3]

(3)

in the formula (2) and the formula (3), A represents a carbon atom, a methylene group, a methylene group substituted with an alkyl group having 1 to 4 carbon atoms, a methylene group substituted with a phenyl group, a methylene group substituted with a naphthyl group, a bimethylene group substituted with a phenyl group, a methylene group substituted with a 9-fluorenyl group, or a methylene group in which an alkyl group is further aromatic nucleus-substituted on the phenyl group, the naphthyl group or the biphenyl group, R_1 to R_6 represent a methyl group, p_1, p_2, p_5, p_6 each

independently represents an integer of 0 to 3, and p_3 and p_4 each independently represents an integer of 0 to 2,
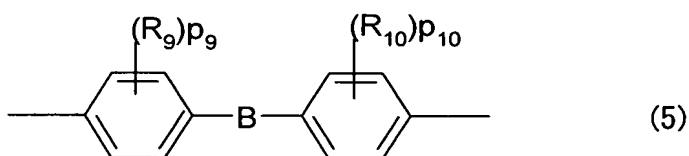
the following formula (4):

[Chemical formula 4]

$$(4)$$
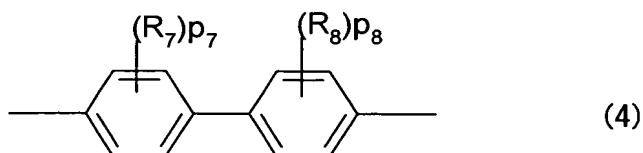
in the formula (4), R_7 and R_8 represent a methyl group, and p_7 and p_8 each independently represents an integer of 0 to 4, and

the following formula (5):

[Chemical formula 5]

$$(5)$$

in the formula (5), B represents $-C(CH_3)_2-$, $-CH(CH_3)-$, $-CH_2-$, $-C(CH_3)(CH_2CH_3)-$, $-C(CH_3)(C_6H_5)-$ or $-SO_2-$, R_9 and R_{10} represent a methyl group or a halogen atom, and p_9 and p_{10} each independently represents an integer of 0 to 4, and may vary with a repeating unit, and

X_2 is a divalent group selected from those represented by the above formulas (2) to (5) and the following formula (6):

[Chemical formula 6]

$$—\overset{(R_{11})p_{11}}{\underset{}{\bigcirc}}—D—\overset{(R_{12})p_{12}}{\underset{}{\bigcirc}}— \quad (6)$$

in the formula (6), D represents $-C(CH_3)_2-$, $-CH(CH_3)-$, $-CH_2-$,

$-C(CH_3)(CH_2CH_3)-$ or $-C(CH_3)(C_6H_5)$, R_{11} and R_{12} represents a

methyl group, and p_{11} and p_{12} each independently represents
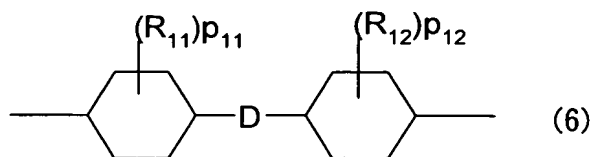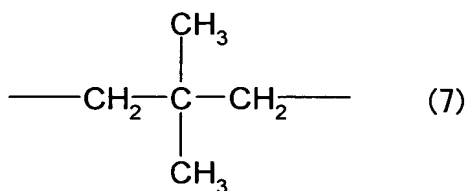
an integer of 0 to 4,

the following formula (7):

[Chemical formula 7]

$$—CH_2—\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}—CH_2— \quad (7)$$

the following formula (8):

[Chemical formula 8]

$$—\left(CH_2—CH_2—O\right)_q CH_2—CH_2— \quad (8)$$
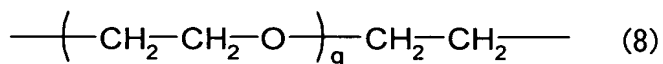
in the formula (8), q represents an integer of 0 to 100, and

the following formula (9):

[Chemical formula 9]

$$—\left(CH_2—\overset{\overset{\displaystyle CH_3}{|}}{CH}—O\right)_s CH_2—\overset{\overset{\displaystyle CH_3}{|}}{CH}— \quad (9)$$
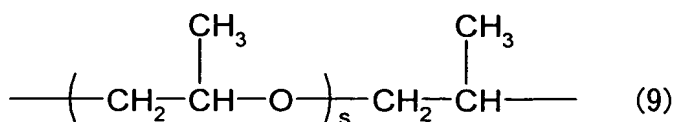
in the formula (9), s represents an integer of 0 to 100, and

may vary with a repeating unit.

3.   The comb-shaped epoxy resin according to claim 1 or 2, wherein the linear polymer chain composed of at least one of the ethyleneimine structural unit and the N-acylethyleneimine unit is represented by at least one selected from those represented by the following formula (10):
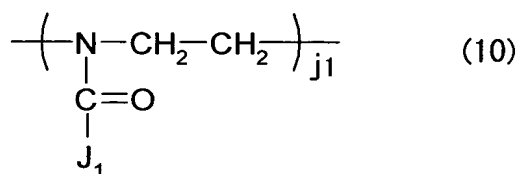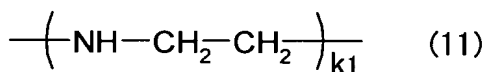
[Chemical formula 10]

$$\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_1 \end{array}\!\!\right)_{j1} \qquad (10)$$

in the formula (10), J_1 represents a hydrogen atom, an alkyl group having 1 to 18 carbon atoms or an aryl group having 6 to 36 carbon atoms, and j_1 is within a range from 5 to 2,000, the following formula (11):

[Chemical formula 11]

$$\left(\!\!\begin{array}{c} NH-CH_2-CH_2 \end{array}\!\!\right)_{k1} \qquad (11)$$

in the formula (11), k_1 is within a range from 5 to 2,000, the following formula (12):

[Chemical formula 12]

$$\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_2 \end{array}\!\!\right)_{j2}\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_3 \end{array}\!\!\right)_{j3} \qquad (12)$$

in the formula (12), J_2 and J_3 represent a hydrogen atom, an alkyl group having 1 to 18 carbon atoms or an aryl group having 6 to 36 carbon atoms, each being different, and j_2+j_3 is within a range from 5 to 2,000,

the following formula (13):

[Chemical formula 13]

$$\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_4 \end{array}\!\!\right)_{j4}\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_5 \end{array}\!\!\right)_{j5}\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_6 \end{array}\!\!\right)_{j6} \quad (13)$$

in the formula (13), J_4 to J_6 represent a hydrogen atom, an alkyl group having 1 to 18 carbon atoms or an aryl group having 6 to 36 carbon atoms, each being different, and $j_4+j_5+j_6$ is within a range from 5 to 2,000,

the following formula (14):

[Chemical formula 14]

$$\left(\!\!\begin{array}{c} N-CH_2-CH_2 \\ | \\ C=O \\ | \\ J_7 \end{array}\!\!\right)_{j7}\left(\!\!\begin{array}{c} NH-CH_2-CH_2 \end{array}\!\!\right)_{k2} \quad (14)$$
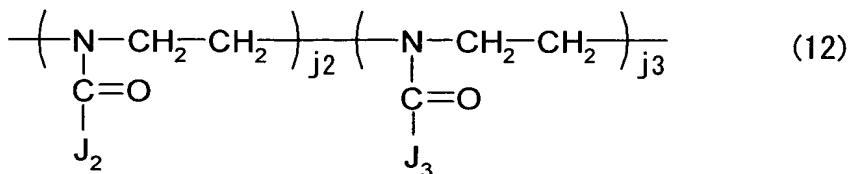
in the formula (14), J_7 represents a hydrogen atom, an alkyl group having 1 to 18 carbon atoms or an aryl group having 6 to 36 carbon atoms, and j_7+k_2 is within a range from 5 to 2,000,

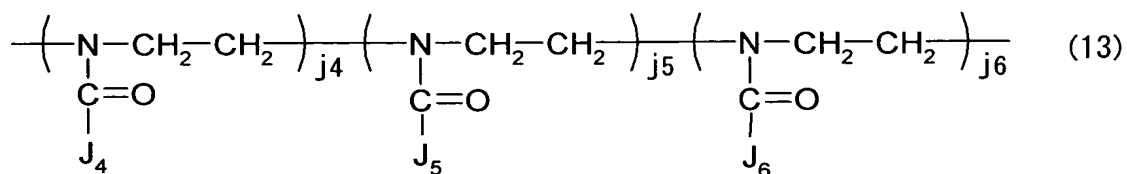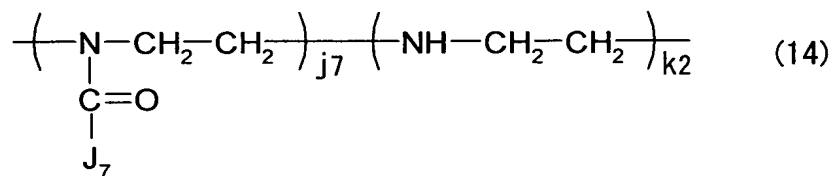the following formula (15):

[Chemical formula 15]

$$\left(\!\!\begin{array}{c} \text{N}-\text{CH}_2-\text{CH}_2 \\ | \\ \text{C}=\text{O} \\ | \\ \text{J}_8 \end{array}\!\!\right)_{\!\!j8} \left(\!\!\begin{array}{c} \text{N}-\text{CH}_2-\text{CH}_2 \\ | \\ \text{C}=\text{O} \\ | \\ \text{J}_9 \end{array}\!\!\right)_{\!\!j9} \left(\!\!\begin{array}{c} \text{NH}-\text{CH}_2-\text{CH}_2 \end{array}\!\!\right)_{\!\!k3} \quad (15)$$
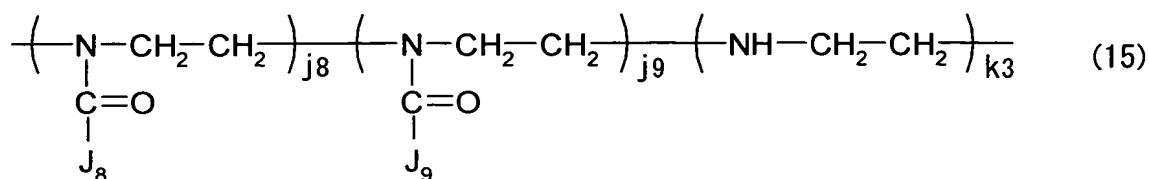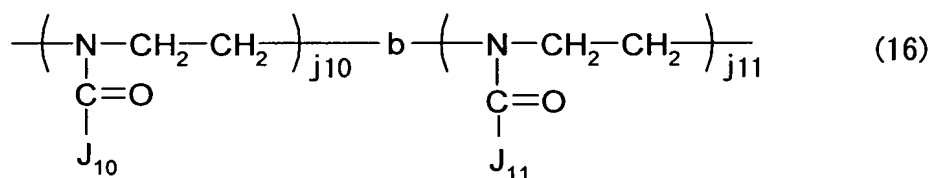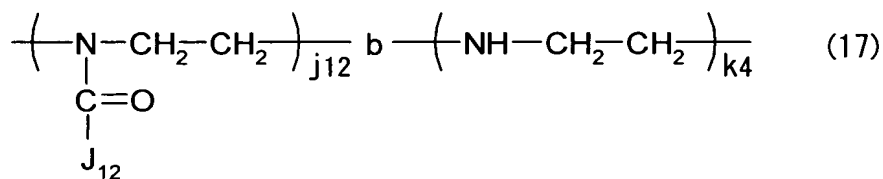
in the formula (15), J_8 and J_9 represent a hydrogen atom, an

alkyl group having 1 to 18 carbon atoms or an aryl group

having 6 to 36 carbon atoms, each being different, and

$j_8 + j_9 + k_2$ is within a range from 5 to 2,000,

the following formula (16):

[Chemical formula 16]

$$\left(\!\!\begin{array}{c} \text{N}-\text{CH}_2-\text{CH}_2 \\ | \\ \text{C}=\text{O} \\ | \\ \text{J}_{10} \end{array}\!\!\right)_{\!\!j10} -\text{b}- \left(\!\!\begin{array}{c} \text{N}-\text{CH}_2-\text{CH}_2 \\ | \\ \text{C}=\text{O} \\ | \\ \text{J}_{11} \end{array}\!\!\right)_{\!\!j11} \quad (16)$$

in the formula (16), J_{10} and J_{11} represent a hydrogen atom,

an alkyl group having 1 to 18 carbon atoms or an aryl group

having 6 to 36 carbon atoms, each being different, $j_{10} + j_{11}$ is

within a range from 5 to 2,000, and b represents a block

polymer composed of a block of each structural unit, and

the following formula (17):

[Chemical formula 17]

$$\left(\!\!\begin{array}{c} \text{N}-\text{CH}_2-\text{CH}_2 \\ | \\ \text{C}=\text{O} \\ | \\ \text{J}_{12} \end{array}\!\!\right)_{\!\!j12} \text{b} -\left(\!\!\begin{array}{c} \text{NH}-\text{CH}_2-\text{CH}_2 \end{array}\!\!\right)_{\!\!k4} \quad (17)$$

in the formula (17), J_{12} represents an alkyl group having 1 to 18 carbon atoms or an aryl group having 6 to 36 carbon atoms, $j_{12}+k_4$ is within a range from 5 to 2,000, and b represents a block polymer composed of a block of each structural unit.

4.   The comb-shaped epoxy resin according to claim 3, wherein J_1 to J_{11} in the formulas (10) to (16) are groups selected from the group consisting of hydrogen atom, methyl group, ethyl group and phenyl group, and J_{12} in the formula (17) is a group selected from the group consisting of methyl group, ethyl group and phenyl group.

5.   The comb-shaped epoxy resin according to claim 1 or 2, wherein the polymer chain composed of the polyethyleneimine-polyalkylene ether block unit is represented by the following formula (18):

[Chemical formula 18]

$$\left(NH\!-\!CH_2\!-\!CH_2 \right)_{k5} \left(O\!-\!T \right)_{L1} \tag{18}$$
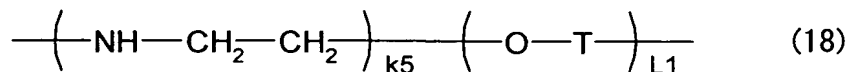
in the formula (18), k5 is within a range from 5 to 2,000, T is an alkylene group having 2 to 4 carbon atoms, and L1 is within a range from 5 to 2,000.

6.   The comb-shaped epoxy resin according to claim 1 or 2,
wherein the polymer chain composed of the poly N-
acylethyleneimine-polyalkylene ether block unit is
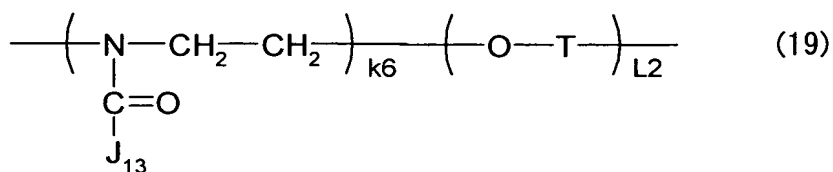represented by the following formula (19)

[Chemical formula 19]

$$-\left(N-CH_2-CH_2\right)_{k6}\left(O-T\right)_{L2}\quad(19)$$
$$\underset{\underset{J_{13}}{|}}{\overset{|}{C}}=O$$

in the formula (19), k6 is within a range from 5 to 2,000,
J_{13} is a group selected from the group consisting of hydrogen
atom, methyl group, ethyl group and phenyl group, T is an
alkylene group having 2 to 4 carbon atoms, and L2 is within a
range from 5 to 2,000.

7.   A method for preparing a comb-shaped epoxy resin
comprising a main chain composed of an epoxy resin skeleton
having an propylene unit, and a linear polymer chain obtained
by polymerizing a cationic polymerizable monomer as a side
chain, which comprises the steps of using, as a cation
polymerization initiator, a modified epoxy resin wherein a
hydroxy group of a side chain of a secondary alcohol
structure moiety in an epoxy resin having a secondary alcohol
structure is substituted with an alkylsulfonyloxy group or an

arylsulfonyloxy group, and cation-polymerizing a monomer capable of being polymerized by cation polymerization from the side chain substituted with the alkylsulfonyloxy group or the arylsulfonyloxy group in the modified epoxy resin.

8.   The method for preparing a comb-shaped epoxy resin according to claim 7, wherein the alkylsulfonyloxy group or the arylsulfonyloxy group is selected from the group consisting of methanesulfonyloxy group, trifluoromethanesulfonyloxy group, trichloromethanesulfonyloxy group, benzenesulfonyloxy group, p-toluenesulfonyloxy group, 2-nitrobenzenesulfonyloxy group and 2,4-dinitrobenzenesulfonyloxy group.

9.   The method for preparing a comb-shaped epoxy resin according to claim 7 or 8, wherein the cationic polymerizable monomer is at least one selected from alkyleneimine monomer, oxazoline monomer, oxirane monomer, oxetane monomer, vinylether monomer and acetal monomer.

10.   The method for preparing a comb-shaped epoxy resin according to claim 7 or 8, wherein the monomer capable of being polymerized by cationic polymerization is an oxazoline monomer.

11. A method for preparing a comb-shaped epoxy resin, comprising a polymer chain containing an ethyleneimine structural unit as a side chain, which comprises the step of hydrolyzing all or portion of N-acylethyleneimine structural units in the comb-shaped epoxy resin comprising a main chain composed of an epoxy resin skeleton having a propylene unit and a polymer chain composed of N-acylethyleneimine structural units obtained by cation polymerization of an oxazoline monomer obtained by the method of claim 10, thereby converting all or portion of the side chains into ethyleneimine structural units.

12. A method for preparing a comb-shaped epoxy resin, comprising a polymer chain composed of a poly N-acylethyleneimine-polyalkylene ether block unit in a side chain, which comprises the step of substituting an active terminal sulfonyloxy residue of the polymer chain in the comb-shaped epoxy resin comprising a main chain composed of an epoxy resin skeleton having a propylene unit and a polymer chain composed of N-acylethyleneimine structural units obtained by cation polymerization of an oxazoline monomer obtained by the method of claim 10 with polyalkylene glycol.

13. A method for preparing a comb-shaped epoxy resin, comprising a polyethyleneimine-polyalkylene ether block unit

in a side chain, which comprises the steps of substituting an
active terminal sulfonyloxy residue of the polymer chain in
the comb-shaped epoxy resin having a main chain composed of
an epoxy resin skeleton having a propylene unit and a polymer
chain composed of N-acylethyleneimine structural units
obtained by cation polymerization of an oxazoline monomer
obtained by the method of claim 10 with polyalkylene glycol,
and hydrolyzing the N-acylethyleneimine unit in the polymer
chain.